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SAIC0006-US PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of

Richard L. Sutherland, et al. Art Unit: 1756

Serial No. 09/577,166 Examiner: ANGEBRANNDT, M.

Filed: May 24, 2000

For: A SYSTEM AND METHOD FOR REPLICATING VOLUME HOLOGRAMS

Box: Non-Final
Assistant Commissioner of Patents
Washington, D.C. 20231

RECEIVED MAR 26 2002 TC 1700

DECLARATION UNDER 37 C.F.R. § 1.132

Dear Sir:

Richard L. Sutherland declares as follows:

1. I, Richard L. Sutherland, work for Science Applications International Corporation ("SAIC") as a Senior Scientist in the Advanced Technology and Systems Engineering Operation, part of the Technology Analysis and Applications Group.

2. I have a PhD degree in physics with a specialty in optics. I have 23 years of experience working in areas of lasers, optics, holography, electro-optics, nonlinear optics, and liquid crystals.

3. I am qualified in, *inter alia*, the art of optics, including, the specific areas of holography, liquid crystals, spatial light modulators (SLMs), and the like. I have co-authored numerous scientific papers in these and related areas and I am a listed inventor on numerous patents and patent applications currently pending before the United States

and other patent offices. I have authored a handbook in nonlinear optics and have served as an editor for numerous technical conference proceedings in the areas of or related to holography, liquid crystals, and SLMs. Also, for my work in these areas I have been honored as a Fellow of the American Physical Society.

4. As a practicing PhD physicist, I have sufficient qualifications and first-hand knowledge to assess the predictability of combining various optical components to achieve a specified result.

5. Having the foregoing position and qualifications, I have observed the following.

6. I have read and reviewed the Application, the Final Office Action, the references cited by the Examiner in the Final Office Action and the Response to the Final Office Action which my Declaration accompanies.

7. On pages 3 to 4 of the Office Action, the Examiner asserts that Hall et al. (United States Patent No. 5,471,326) ("Hall") "teaches the use of computer generated holograms for copying processes and Amako et al. '214 teaches means for their generation as well as the advantages that a number of different holograms can be replayed without moving the master or the need to generate a (sic) optically produced master. These are clear advantages to the use of computer generated holograms in LC materials as the masters." Contrary to the Examiner's assertion, I declare that the combination of the teachings of Hall with the teachings of Amako et al. (Unites States Patent No. 5,682,214) ("Amako") cannot reasonably be expected to result in the claimed

subject matter. More particularly, the computer generated hologram (CGH) in an LC (liquid crystal) device described in Amako cannot be used as a master hologram for contact printing to produce a replica thereof.

8. As is well known in the art, in contact printing the master and replica are optically contacted and irradiated with a single, coherent reference beam. The master faithfully reproduces the desired object beam from the reference beam. This object beam interferes with the reference beam in the replica material to faithfully replicate the master hologram. The replicated hologram is physically formed by two-beam holography, and will only form a faithful replica of the master if the master faithfully reproduces the desired object beam. Using the CGH in LC device described in Amako as a master will not have this result.

9. The LC devices discussed in the teachings of Amako include a twisted nematic (TN) LC device and an electrically controlled birefringence (ECB) LC device. The former, together with external polarizers, is used to make CGH amplitude gratings, while the latter is used to make CGH phase gratings. Devices like these are taught in all the embodiments of the Amako patent. In some cases, TN and ECB devices are combined in more complicated arrangements. The basic devices employ thin film transistor (TFT) active matrix switches for controlling individual pixels. These are standard devices used in the industry of LC displays and spatial light modulators.

10. Active matrix displays are discussed extensively in <u>Optics of Liquid Crystal Displays</u> (P. Yeh and C. Gu, John Wiley & Sons, New York, 1990, p. 252-267).

On p. 262 of Yeh et al., the authors give a table comparing three common TFT materials: amorphous silicon (a-Si), poly-Si, and cadmium selenide (CdSe). Based on panel size and number of pixels, the pixel size may be estimated. For a-Si (14 in., 1100×1440 pixels) this is 323 μm × 247 μm; for poly-Si (9.5 in., 480×960 pixels) this is 503 μm × 251 μm; and for CdSe (9.5 in., 400×600 pixels) this is 603 μm × 402 μm. Amako give examples that are more optimistic: column 4, lines 13-17 describe a 19 mm × 14 mm display area with 320×220 pixels, yielding pixel size of 59 μm × 64 μm; column 9, lines 12-22 give an argument for reducing the pixel size to 40 μm × 45 μm. The schemes involved for the latter, i.e., pixel size of 40 μm × 45 μm, most certainly could not be achieved in a thin device for contact printing (see Fig. 10 of Amako). However, for the sake of argument, taking even the most optimistic pixel size stated in Amako, 40 μm, it can be seen that the smallest limit for the pitch of a CGH in an LC device would be on the order of 80 μm. This is because it takes a minimum of two pixels to define the pitch (e.g., one pixel switched on and an adjacent pixel switched off). Contrast this with the pitch size of 0.1-1.0 μm in the holographic polymer-dispersed liquid crystals (HPDLCs) used in the current invention. This significantly reduced pitch size is necessary to the successful contact printing and replication of a variable diffraction efficiency master hologram. Clearly, there is a disparity in pitch size based on current TFT active matrix technology as described in Amako. Further, there is no evidence that this size discrepancy can be overcome in the near future.

11. Next, consider the type of hologram that can be made by a CGH in an LC device. Holographic gratings are generally described as belonging to one of two regimes: the Bragg regime and the Raman-Nath regime. Most literature sources define these regimes with reference to a parameter Q, defined by

$$Q = 2\pi\frac{\lambda d}{n\Lambda^2}$$

where λ is the optical wavelength, d is the hologram thickness, n is the index of refraction for the hologram material, and Λ is the grating pitch (see L. Solymar and D. J. Cooke, Volume Holography and Volume Gratings, Academic Press, New York, 1981, p. 128). Holograms with Q<<1 are in the Raman-Nath regime, and holograms with Q>>1 are in the Bragg regime. Using the numbers for a visible HeNe laser wavelength (λ=0.633 μm) and a typical refractive index of n=1.5 for most LCs, glass, and polymers, Q can be calculated for the CGH in LC devices and for a typical HPDLC grating. For the CGH in LC with Λ=80 μm and d=10 μm, Q=0.004. Note that to make Q as large as 1 would require $d\approx$2400 μm=2.4 mm, which is completely unrealistic for LC devices. For an HPDLC with Λ=0.2 μm and d=10 μm, Q=663. Clearly, the HPDLC described in the pending application is in the Bragg regime and the CGH in LC is in the Raman-Nath regime. Raman-Nath gratings are analyzed in J. W. Goodman, Introduction to Fourier Optics, McGraw-Hill, New York, 1968, pp. 66-70. The two types of gratings in the teachings of Amako are amplitude and phase gratings. The diffraction pattern for an

amplitude grating consists of the zero-order (i.e., transmitted beam) and two side-orders. The maximum efficiency of the side-orders is 25% of the zero-order. A phase grating produces multiple side-orders, an infinite number in theory, but easily 6-10 orders are usually visible. The maximum efficiency of the first side-order is 34%. A Raman-Nath grating cannot faithfully reproduce the object wave of the master, since the master is written with only two beams (reference and object) or the equivalent thereof for a CGH. Since the Raman-Nath grating produces multiple diffracted beams, with relatively low efficiency in each beam, the hologram formed by the interference of these beams with the single reference beam will not even remotely resemble the master. On the other hand, a Bragg grating will produce only the zero-order and substantially only one first-order diffracted beam, and the diffraction efficiency of the first-order beam can readily approach 100% (see L. Solymar and D. J. Cooke, Volume Holography and Volume Gratings, Academic Press, New York, 1981, pp. 129-136).

12. Further, the CGH in LC forms only a two-dimensional pattern. This is dictated by the fact that the electrodes are arrayed on the bounding surfaces of the LC device. Hence the index modulation can only be induced in the plane of the LC device. This by definition forms a transmission grating, i.e., the diffracted beams emanate from the side opposite the impinging beam. Therefore, a CGH in LC cannot form a reflection grating, where the index modulation is perpendicular to the bounding surfaces. The only way it could do this would be to distribute the electrodes through the volume of the LC, which is not even remotely possible with current or foreseeable active matrix technology.

Claims 12-21 refer to the formation of reflection holograms; the formation of reflection holograms clearly exceeds the capability of a CGH in LC even if the pixel size restriction described in paragraph 9 could be overcome. Although one of the embodiments of Amako appears to allow reflections, this is only due to a reflection from an ordinary mirror built into the LC device and is not a reflection property of the hologram. The latter is required for contact printing of reflection holograms.

13. In conclusion, the CGH in an LC device described in Amako cannot be used as a master hologram with variable diffraction efficiency in a contact printing scheme because of a) its pitch size, b) its inherent limitations in electrode technology that prevent it from achieving Bragg regime diffraction, and c) its inability, even in principle, to form a reflection hologram.

14. I further declare that all statements made herein of my own knowledge are true and that all statements made on information or belief are believed to be true, and further that the foregoing statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001, and that such willful false statements may jeopardize the validity of the above-referenced application or any patent issuing thereon.

Date: Feb. 22, 2002

Signed: Richard L. Sutherland

Richard L. Sutherland